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THE CALENDAR

BY

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PREFATORY NOTE

The following paper was written to be read before the Scientific Club of the University of Michigan. The writer has used very freely material found in calendars and almanacs, and books and encyclopedia articles on calendars, almanacs and chronology. He has avoided any very technical treatment of the subject. His excuse for having the paper appear in print is the request of friends that it be printed for private distribution.

THE CALENDAR

Why do we celebrate Washington's birthday on February 22, when the father of our country was born February 11, 1731; and how did he come to be less than 68 years old when he died Dec. 14, 1799? The answer is to be found in the reform of the calendar taking place in 1752 when the day following September second was by act of the British Parliament made September 14, and New Year's Day was changed from the Feast of the Annunciation or Lady Day, i. e., March 25, to the first of January. Had the change been made before Washington's birth he would have had February 22, 1732 for his natal day. In the year 1889 I enjoyed over six weeks (to be accurate, forty-three days) of August in travel in Northern Europe, but September was cut short for me, so that it had only 18 days. Yes, I am quite truthful and the answer is to be found in the fact that I was traveling in Sweden, Russia and Germany, and Russia still uses the Julian calendar, under a modified form of which Washington was born but did not die. I have thought it might interest the Scientific Club to spend an evening with the calendar. I do not refer to the university's calendar with respect to which we had a warm but good natured discussion at a recent senate meeting. My paper has to do with calendars in general.

It is quite superfluous for me to tell you that the word calendar (Latin kalendarium) takes its name from the kalendae i. e., the first day of the month in the Roman calendar, a kalendarium being a book in which memoranda were kept.

All nations or races of men have ways of keeping account of time. Since the earliest ages men have had days, months, seasons and years. Of these the day is perhaps the only unit accepted in substantially the same form by all men; but even the day, as determined by noon to noon measurements, has no fixed length; for the varying motion of the earth about the sun makes each solar day different in length from neighboring days. Before the invention, or rather the perfecting, of clocks. no attempt was made to fix a uniform length of time for a day, but the time from sunset to sunrise was called the night and divided into twelve hours; and the time from sunrise to sunset, similarly divided, was called the day. The hours of the day and those of the night were at most times of different length, those of the day being longer here in the northern hemisphere from spring to fall than those of the night, and vice versa from fall to spring. With the perfecting of clocks we have invented a uniform day of twenty-four uniform hours. If one refers to an almanac for 1908 he will notice that noon by the sun does not occur at 12 o'clock except

four times a year, April 15, June 14, September 1 and December 25. The maximum errors occur on February 12 when the real sun is 14 m., 26 s. late in passing the meridian, on May 15 when it is too early by 3 m. 49 s. on July 26 when it is 6 m. 18 s. late, and last on Nov. 3 when it is 16 m. 20 s. too early. The variations from day to day may be plotted in a curve graphically representing the equation of time.

Waiving these small variations aside as being too inconsequential to be considered, it may interest you to know that while, like the ancient Egyptians, we commonly divide days from one another at midnight, it has not always been done so by all nations. Astronomers and navigators measure the day from noon to noon, the astronomical day beginning 12 hours after the civil day of the same date. Like the ancient Chaldeans, the modern Greeks commence their day at sunrise. Our forefathers followed the Hebrews in beginning the twenty-four hour period at sundown, roughly six hours in advance of the present civil day. As a child I was always puzzled to hear in the account of the creation in the Bible the words, "and the evening and the morning were the first day" or "the second day," etc. The Jews continue to the present time beginning their day at sundown. Our method of counting hours from noon and midnight is modern, for the ancients, as a general rule, counted from sunset to sunrise, and again from sunrise to sunset. The laborers who went to work in the vineyard at the eleventh hour and received a penny, much to the disgust of their fellow laborers, went to work at say 5 p. m. and not at 11 a. m., as many of us doubtless thought as children when hearing the account. Our clocks and watches record time up to 12 hours to correspond with our a. m. or morning and p. m. or afternoon. Astronomers and some few railroads count from 1 to 24 inclusive, and it has been suggested that watches be made to indicate twenty-four hours.

The month—or the time of an apparent revolution of the moon about the earth—was necessarily observed by primitive man. It is a period of about 29½ days and is somewhat irregular. In fact it is far more irregular than the solar day. The average value of this apparent revolution technically called a synodical month or lunation is 29.53059 days. Our year, made up of the four recurring seasons, includes more than twelve lunations and less than thirteen. As a natural period of time the month of the moon took a very strong hold on man and we find most of the early calendars trying to accommodate the year to some whole number of lunations. For example the Hebrew year consists of twelve lunations in ordinary years and thirteen lunations in embolismic years (*ἐμβάλλειν* to throw in). The ordinary year has 353, 354 or 355 days and the embolismic year 383, 384 or 385 days. This variation of a day or two is due to the fact that it is not allowable for a year to begin on Sunday, Wednesday or Friday, and if new moon should so fall, New Year's Day goes over one day. The Hebrew civil year begins with the new moon following the autumnal equinox. The religious year begins with the month Nisan after the vernal equinox. Hebrew years are numbered from the

creation of the world which is said by the Hebrew authorities to have occurred 3,760 years, 3 months before the beginning of the Christian era. There seems to be some dispute as to when the creation actually took place, for Julius Africanus decided the weight of authority put the creation of Adam 5,500 years before the birth of Christ. A high Irish authority, Arch-Bishop Ussher, following a Hebrew account, puts the creation at 4,004 B. C. The septuagint is quoted in support of the proper time being 5,411 B. C.

Another interesting year was the Olympic, of which a group of four was called an Olympiad. The Olympic games came every fourth year, and the name of the victor at the games was given to the Olympiad just starting. Corœbus was the first victor to have this honor done him, and his olympiad began about the time of the summer solstice, B. C. 776. The year began with the full moon near the summer solstice (either before or after). This year sometimes included 12 and sometimes 13 lunations. The Greek astronomer Meton discovered the lunar-solar cycle, known as the metonic cycle, in which 235 lunations approximately equal 19 years of which 12 have 12 lunations and 7 (i. e. the 3rd, 6th, 8th, 11th, 14th, 16th and 19th) have 13 lunations. This correspondence is very close, as will be seen later. The Olympic year starting June 27, B. C. 432 was the first to follow the Metonic cycle. Thereafter the Olympic year began on the 11th day of the moon following the summer solstice. To reduce olympiads if before the beginning of the Christian era to our dates, the rule is: Multiply the whole number of olympiads by four, add the number of years in excess and subtract the sum from 776 or 777, depending on the time of year. The remainder is the year B. C. For events in the Christian era, 775 or 776 is subtracted from the above sum. The Mohametan year is made up of twelve lunations (354 or 355 days) and makes no attempt to keep the recurring seasons in the same place in the year. Their New Year's Day moves backward through the seasons, occurring each year eleven or twelve days earlier than in the previous year. Such a year is technically called vague. The prophet is said to have fled from Mecca to Medina July 15, 622 A. D., and the first year of the Mohametan era dates from the following day, July 16, 622. It is said by some that the prophet did not actually leave until some time later, but merely went into hiding on July 15. This however has not been allowed for in the date of the beginning of their era.

The Egyptians, like the Persians, had a year of 365 days. They paid no attention to lunations in their months which had 30 days each, with five supplementary days at the end of the year. The Egyptian day began at midnight. Their astronomers knew that the year was too short; and about B. C. 25 they followed the Romans in introducing an intercalary day one year in four. The Persian era of 365 days began with an eclipse February 26, 747 B. C. The astronomer Omar Cheyam is reputed to have devised an intercalary day every fourth year for eight periods of four years, followed by an intercalary day

at the end of five years. This cycle of 33 years with 8 intercalary days is more accurate than the Gregorian cycle of 400 years by about 6.5 seconds per annum, as will be seen later.

The Roman year differed so much at different times that it is practically impossible to locate dates with any sort of precision. Romulus was said to have divided the year into ten months including 304 days, but no one seems to have any idea of what became of the rest of the days. The year began with March and the months were named in numerical order ending with September, October, November and December. These names indicate that these were the 7th, 8th, 9th and 10th months. The 5th and 6th months Quintilis and Sextilis were renamed for Julius Cæsar and Augustus Cæsar, our July and August. In the time of Numa January was added at the beginning and February at the end, making twelve months in all. In 452 B. C. the Decemvirs brought February from the end of the year to a place between January and March. These months consisted alternately of 29 and 30 days, averaging 29½ days, roughly the period of a lunation. The Encyclopedia Britanica says that they added one day for luck, as 12 lunations comprised 354 days, an even and supposedly unlucky number. To bring the year back to the same point in the seasons Numa introduced intercalary months of 22 and 23 days alternately between February 23 and 24 every second year. This made the year average 366¼ days. As this year was about one day too long, every 24 years one of the intercalary months was dropped out and another reduced from 23 to 22 days, thus reducing the average length of year to 365¼ days. I do not know why the extra month (Mercedonius) was intercalated in what seems such an odd place, between the 24th and 25th of February, i. e., the 7th and 6th days before the kalends of March; but this place of intercalation remains in use by the Roman Catholic church to the present day. It is now only of a single day every fourth year. To this I shall return later. The administration of the Roman calendar was in the hands of the pontifix maximus, and he at various times is reputed to have used his power over the calendar for political ends, at times prolonging men in office and at other times cutting them short by the manipulation of the intercalary months.

This complicated calendar was brought to an end by Julius Cæsar who introduced the Julian calendar to go into effect January 1, B. C. 45. The principal change was lengthening the month by one day making them alternate 31 and 30 days, with February having 30 days in leap years only. The extra day was intercalated one year in four by a doubling of the 6th day before the calends of March, i. e., an extra 24th day of February was put in after* the regular 24th day. Because of the doubling of the 6th day before the calends, leap years became known as bissextile, and in fact are so called by many people though the doubling of the 6th day before the calends of March has disappeared from all calendars except that of the church.

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*Now before the 24th, as changed by Augustus Caesar.

Although the Julian calendar went into effect on paper January 1, B. C. 45, it was so little understood that many errors were made in the intercalation and some slight confusion in exact dates of events has resulted. Augustus Cæsar disturbed the regular alternation of 31 and 30 days because being undesirous that his month, August, should be inferior to July, he added a day to August bringing it up to 31, and also changed the order of the 31-30 alternation in the following months to December inclusive, and finally reduced February to 28 days in common years. The Julian calendar which went into effect January 1, B. C. 45, led to the numeration of the years reckoning from that date. This mode of numeration is known as of the Julian era. Roman dates are however more commonly referred to "after the building of the city" by Romulus which was estimated by various authorities to have taken place B. C. 747, 750, 751, 752 or 753. Cicero for example accepted what is equivalent to 753 as right, I believe, for the year in which Christ was supposed to have been born. Andrews in his Life of Christ accepts B. C. 5 as the year of Christ's birth, so there is much confusion as to conversion of dates of the Roman calendar into accurate B. C. and A. D. dates.

The Julian calendar with the years numerated from the supposed year of Christ's birth has come down through the ages. The date chosen for New Year's Day has been variously chosen. In general the 1st of January has been New Year's Day, but many authorities have considered December 25, the supposed day of Christ's birth, the corect date. Others however following Dionysius reckon the years from the date of the annunciation by the angel to Mary nine months before (March 25) as the correct New Year's Day. As a consequence the position of a year identified by a certain number was put back 9 months 7 days with respect to the usual style of reckoning. The practice of putting New Year's Day back, later gave way to advancing it 2 months 24 days, so that the year of the usual era and of the era of the Incarnation, as it was called, agreed in numeration from March 25th through the balance of the year. In England after the 7th century, it was usual to treat Christmas as New Year's Day, and this continued to the 13th century, though in the 12th century we find the civil year beginning with the Feast of the Annunciation or Lady-Day (March 25). The 25th of March later became generally accepted and legalized as New Years and continued as such (as earlier mentioned) until Parliament in 1751 passed the act reforming the calendar, by which the day following September 2, 1752 became September 14, and the modified Julian calendar known as the Gregorian calendar was put in force in England and her colonies. Scotland had introduced new style somewhat earlier (January 1, 1600). Old style is still used in Russia, Greece and the other countries under the influence of the Greek church. Their calendars are behind ours 13 days, today (May 9th) being by their Calendar April 26. No further change will occur until 2100 A. D. Even in this country a trace of the era of the Incarnation remains in the fiscal year of

Delaware which begins March 25. January first is now universally taken as New Year's Day by Christian nations.

The differences between old style and new style have caused many difficulties for persons looking up family records. The difference in the old and new styles which perhaps has caused the most bewilderment is the fact that New Year's Day old style was March 25. In one particular instance, an ancestor of a certain gentleman was born in February of a year early in the eighteenth century of parents who were married in April of the same year. The facts of the case caused no comment at the time, but did worry the gentleman who was looking up his family tree. He was much relieved to find that the year of old style began March 25.

The error in the Julian calendar though slight, gradually accumulated through the ages, for 365¼ days is in fact 11 m. 14 sec. too long for the average year. When the Julian calendar was introduced B. C. 45 the vernal equinox is said to have fallen on March 25. By the time of the council of Nice, 325 A. D., the equinox had retrograded to March 21 and in 1582 it had retrograded to March 11. I believe the first date March 25 to be one day in error; for 11 m. 14 sec. per annum for 370 years up to the council of Nice makes a total of a little less than 3 days, not 4 as commonly supposed.

The gradually accumulating error of the Julian calendar was known by astronomers, and another reform of the calendar was frequently suggested. Pope Gregory XIII. after consultation with the authorities of the various Catholic countries ordered that the day following October 4, 1582 should be October 15th, thus dropping out 10 days and restoring the vernal equinox to the 21st of March, the position it had occupied at the time of the council of Nice. In order that further error might be avoided Gregory ordered that years at the end of centuries, not divisible by 400, should be common years and when divisible by 400, leap years. Thus 1600 was a leap year; but 1700, 1800 and 1900 were not. Three days spread over 400 years are equivalent to 10 m. 48 sec. per year. The former error of 11 m. 14 sec. was thus reduced to 26 sec., equivalent to an error of one day in 3,323 years. It has been suggested that the small remaining error might be reduced by making years divisible by 4,000, common years. This however is not a part of the Gregorian scheme.

At this season of the year the movable feasts of the church, especially Easter, are matters of interest, and I may not unduly weary you if I describe how Easter is found. In the Jewish calendar the Passover is the fourteenth day of the month Nisan, which starts at the vernal equinox. There is much confusion among the authorities to which I have referred, as to whether the preparations for the Passover were made on the 14 day of Nisan, and at sundown the beginning of the 15th the Passover commenced; or whether the 14th day was the first day of the Passover, and the preparations of necessity were made on the 13th. I have taken the latter view to be right, viz., that the 14th of Nisan was the first day of the

passover and the last day the 21st. Briggs in his *New Light on the Life of Jesus* takes this view. The *Britanica* is on both sides. The *Century Dictionary* says the 14th. Christ was crucified on the Passover day which began at sundown on what we call Thursday evening, the eve of the first Good Friday. The date in the Julian calendar of that Friday according to Andrews' *Life of Christ* appears to have been April 7, A. D. 30. The early church was very much divided as to when Easter should be celebrated, some followed the Jewish calendar and celebrated Easter on the 14th day of the moon regardless of the day of the week, they being known as quartodecimans. The quartodecimans must it seems to me have celebrated the anniversary of Good Friday rather than that of the Resurrection which appears to have occurred on the 16th day of the month Nisan. However the council of Nice in 325 A. D. settled the question by ordering that Easter be celebrated on the Sunday following the 14th day of the moon falling on or next after the vernal equinox and that the equinox should be deemed to fall on March 21 invariably. Under this rule the earliest day for Easter would be March 22 and the latest April 26. To arrive at the latest date it would be necessary for the moon to be full (14th day) late on March 20 with the following 14th day of the moon April 19 and falling on a Sunday. Under this combination of circumstances Easter would be a week later, April 26. Calling the time of a lunation 29½ days we would have the following chances for Easter to fall in case the rule were followed:

On March 22,	1/7x29.5 = 0.00484,	say once in 206.5 years.
On March 23,	2/7x29.5 = 0.00968,	say once in 103.25 years.
On March 24,	3/7x29.5 = 0.01453,	say once in 68.83 years.
On March 25,	4/7x29.5 = 0.01937,	say once in 51.625 years,
On March 26,	5/7x29.5 = 0.02421,	say once in 41.3 years.
On March 27,	6/7x29.5 = 0.02905,	say once in 34.415 years.
On March 28, and all dates to April 19th inclusive	7/7x29.5 = 0.03390,	say once in 29.5 years.
On April 20,	6.5/7x29.5 = 0.03147,	say once in 31.77 years.
On April 21,	5.5/7x29.5 = 0.02663,	say once in 27.55 years.
On April 22,	4.5/7x29.5 = 0.02179,	say once in 45.88 years.
On April 23,	3.5/7x29.5 = 0.01695,	say once in 59.00 years.
On April 24,	2.5/7x29.5 = 0.01210,	say once in 82.60 years.
On April 25,	1.5/7x29.5 = 0.00726,	say once in 137.60 years.
On April 26,	0.5/7x29.5 = 0.00242,	say once in 413.00 years.

For some reason is was considered desirable that the lunar month involved should have 29 days only, and consequently the epacts of the moon, i. e., the day on which it is new, were juggled so that they doubled up on the 4th and 5th of April. This makes it impossible that the 14th day of the moon should fall according to the ecclesiastical tables, on April 19 unless the previous 14th day had fallen on March

21. This makes it impossible for Easter to fall on April 26 and increases the chance of Easter falling on the 19th to the 25th inclusive. I shall not weary you with a new computation.

It is evident that the above rules would leave an uncertainty as to Easter, as it might easily happen that the Easter moon would reach its 14th day while still Saturday say here in Ann Arbor, while it was at the same actual instant Sunday in Rome, Constantinople or Jerusalem. Under the rule the following day would be Easter in Ann Arbor, but in Rome, Constantinople or Jerusalem Easter would go over a week. This difficulty in fact does not exist, as in early days sets of tables (epacts and Sunday letters) were invented showing when the first day of the Easter moon should occur and the day of the week when New Year's Day would fall, or the days of the year when Sundays fall. From these tables the Sunday after the 14th day of the moon on or after the 21st of March is found. When the calendar was revised by Gregory new sets of tables were made. These tables save the possibility of dispute. The tables of epacts are in fact several days wrong as to the mean time of new moons which really average about two days ahead of the tables. Some authorities say the error was intentional to avoid Easter falling on the same date as the Passover. The whole Gregorian calendar using world celebrates Easter according to the tables and regardless of the moon. Our own prayer book naively says:

> But note, that the full moon, for the purposes of these rules and tables, is the fourteenth day of a lunar month, reckoned according to an ancient ecclesiastical computation, and not the real or astronomical full moon.

In coming years the moon will gradually change its divergence from the tables; but as the tables of epacts carry a correction for the Gregorian method of intercalations and also a correction for the Metonic cycle (the former being applied in 1700, 1800, 1900, 2100 2200, 2300, 2500 etc., and the latter in 1800, 2100, 2400, etc.) there will not be much change in the error of the ecclesiastical tables.

The following data as to the lunation and the various years are of interest:

		Days	Hrs.	Min.
19	Siderial years .... require	6,939	20	54
19	Tropical years .... require	6,939	14	27
19	Julian years .... require	6,939	18	00
19	Gregorian years .... require	6,939	14	35
19	Persian years (Omar Cheyam correction) .... require	6,939	14	33
235	Metonic Cycles (mean)............ require	6,939	18	00
235	Metonic Cycles ,corrected (mean).. require	6,939	16	29
235	Lunations (mean) .... require	6,939	16	31

The errors remaining are the differences between:

		Min.
19	Gregorian (mean) and 19 tropical years...............	8
235	Metonic Cycles corrected and 235 lunations..........	2
	Total error in 19 years	10

which is equivalent to a day in about 2,700 years; and it is in the direction of a correction of the error in the ecclesiastical tables, unless the suggestion that the year 4000 and multiples shall be made common years is put in effect, which would make the correction of the tables in 19 years fall to 3 minutes only, which is equivalent to a day in say 9,000 years.

The Greek church (in Russia, Greece and other eastern countries which still use the Julian calendar) celebrates Easter according to the original ecclesiastical tables. Their calendar is now 13 days off from ours, and I believe their Easter averages that number of days later, though of course it is never exactly 13 days later as Easter must fall on Sunday. I have not access to their tables—and they probably would be in a language I could not read should I find them—so I cannot say certainly, but hazard the statement that as the 14th day of the moon fell this year on April 14 our style (April 1 their style) on a Tuesday, that their Easter was probably the same day as ours April 19 new style (April 6 old style). Some years it may fall four or five weeks after ours because of March 21 being taken both styles for the ecclesiastical vernal equinox.

The calendar practically will never repeat as to sequence of dates for Easter, as it takes 28 years for the solar cycle (Julian style) to repeat owing to leap years coming every fourth year and there being seven days in the week. Then the Metonic cycle requires 19 years to repeat, making 28x19 = 532 years for the lunar-solar cycle called the Dionysian Period to repeat. The Gregorian calendar has a correction period of 400 years and the lunar equation corrects every 300 years. So the least period possible is 159,600 years for the calendar, supposing that the suggested amendment of the Grgorial calendar every 4,000 years is not put into force, if the latter correction is accepted, then the period is lengthened to 1,596,000 years before the Easter calendar repeats.

In conclusion I give you a table as to when Easter has fallen or will fall in the twelve lunar cycles of the years 1786 to 2013 incusive:

March 22, 1818.
March 23, 1788, 1845, 1856, 1913, 2008
March 24, 1799, 1940
March 25, 1883, 1894, 1951
March 26, 1815, 1826, 1837, 1967, 1978, 1989
March 27, 1796, 1842, 1853, 1864, 1910, 1921, 1932, 2005
March 28, 1869, 1875, 1880, 1937, 1948
March 29, 1807, 1812, 1891, 1959, 1964, 1970
March 30, 1823, 1834, 1902, 1975, 1986, 1997
March 31, 1793, 1839, 1850, 1861, 1872, 1907, 1918, 1929, 1991, 2002, 2013
April 1, 1804, 1866, 1877, 1888, 1923, 1934, 1945, 1956
April 2, 1809, 1820, 1893, 1899, 1961, 1972
April 3, 1825, 1831, 1836, 1904, 1983, 1988, 1994
April 4, 1790, 1847, 1858, 1915, 1920, 1926, 1999, 2010